Athermal energy loss from X-rays deposited in thin superconducting bilayers on solid substrates

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An important feature that determines the energy resolution of any type of thin film microcalorimeter is the fraction of athermal energy that can be lost to the heat bath prior to the device coming into thermal equilibrium.

We have measured the loss of energy that occurs through athermal processes when a 6 keV X-ray deposits its energy directly into a MoAu bilayer at 40 mK that is fabricated on a solid silicon substrate. The equilibrium temperature change of the bilayer is determined from its change in magnetic susceptibility. The bilayer was attached to a 2.8-micron thick gold absorber. From studies of the temporal profiles of the signals from X-ray events, we can determine which events come from X-rays going into the absorber, and which are deposited directly into the bilayer. From a comparison of the sizes of signals, we have deduced that the fraction of energy that is lost through athermal phonons for the x-rays stopped in the bilayer is approximately 3.8% of the total energy. We have found an evolving phonon distribution function solving the system of kinetic equations for interacting electrons and phonons and modeled the expected energy loss from this bilayer, fluctuations about the mean value and spectral line-shape. These predictions agree well with our measurements using the known parameters of the bilayer such as the Debye energy and the thermal diffusivity.

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